The Distribution and Abundance of Greenland Halibut, Deepwater Redfish, Golden Redfish, Roundnose Grenadier and Roughhead Grenadier in Davis Strait

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THE DISTRIBUTION AND ABUNDANCE OF GREENLAND HALIBUT, DEEPWATER REDFISH, GOLDEN REDFISH, ROUNDNOSE GRENADIER AND ROUGHHEAD GRENADIER IN DAVIS STRAIT

by

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ABSTRACT

Atkinson, D.B., and W.R. Bowering. 1987. The distribution and abundance of Greenland halibut, deepwater redfish, golden redfish, roundnose grenadier and roughhead grenadier in Davis Strait. Can. Tech. Rep. Fish. Aquat. Sci. 1578: v+29 p.

The distribution and abundance of Greenland halibut (*Reinhardtius hippoglossoides* Walbaum), deepwater redfish (*Sebastes mentella* Travin), golden redfish (*Sebastes marinus* L.), roundnose grenadier (*Coryphaenoides rupestris* Gunn.) and roughhead grenadier (*Macrourus berglax* Lacépède) in the Davis Strait area were examined in relation to geographic area, depth and temperature. Greenland halibut was the most abundant species and occurred throughout the area investigated. They were most abundant in depths of 900–1000 m, in bottom temperatures of 1.0–1.9°C. The mean size of these fish increased with depth. Deepwater redfish were also caught throughout the area surveyed and the size of these also increased with depth. They were most abundant in depths of 300–400 m in temperatures greater than 1.9°C. Relatively few golden redfish were encountered and most of these were in NAFO Subarea 1 south of 66° 30'N in depths of 200–400 m and bottom temperatures above 3°C. Roundnose grenadier were also most abundant in Subarea 1 and were not found north of 66° 30' N. They were found in depths greater than 700 m associated with temperatures of about 3.0–4.0°C. As with the other species above, there was an increase in size of roundnose grenadier with depth. Roughhead grenadier were widely distributed both geographically and by depth, but in relatively small numbers. The largest numbers were taken in depths of 700–799 m and temperatures of 1.0–4.9°C.

RÉSUMÉ

Atkinson, D.B., and W.R. Bowering. 1987. The distribution and abundance of Greenland halibut, deepwater redfish, golden redfish, roundnose grenadier and roughhead grenadier in Davis Strait. Can. Tech. Rep. Fish. Aquat. Sci. 1578: v+29 p.

La répartition et l'abondance du flétan du Groenland (*Reinhardtius hippoglossoides* Walbaum), du sébaste atlantique (*Sebastes mentella* Travin), du sébaste orangé (*Sebastes marinus* L.), du grenadier de roche (*Coryphaenoides rupestris*) et du grenadier berglax (*Macrourus berglax* Lacépède) dans le détroit de Davis ont été étudieés en fonction de la région géographique, de la profondeur et de la température. Le flétan du Groenland, espèce la plus abondante et présente dans toute la zone expérimentale, était présente en plus grand nombre à des profondeurs allant de 900 à 1000 m et à des températures au fond variant de 1.0 à 1.9°C. De plus, sa taille moyenne augmentait en fonction de la profondeur. Le sébaste atlantique a aussi été capturé dans toute la zone expérimentale et sa taille augmentait en fonction de la profondeur. Il était plus abondant à des profondeurs

allant de 300 à 400 m et à des températures supérieures à 1.9°C. En proportion, un faible nombre de sébaste orangé a été capturé dont la plus grande partie provient de la sous-zone 1 de l'OPANO, au sud de 66° 30' de latitude nord à des profondeurs variant de 200 à 400 m et à des températures au fond supérieures à 3°C. Le grenadier de roche était aussi plus abondant dans la sous-zone 1 jusqu'à 66° 30' de latitude nord. Il fréquentait des profondeurs supérieures à 700 m où la température variait d'environ 3.0 à 4.0°C. Comme c'était le cas chez les autres espéces susmentionnées, la longeure de ce grenadier augmentait en fonction de la profondeur. Le grenadier berglax, relativement peu abondant, était par contre communément retrouvé dans la zone expérimentale et à toutes les profondeurs. Il était présent en plus grand nombre à des profondeurs allant de 700 à 799 m et à des températures variant de 1.0 à 4.9°C.

Introduction

The Davis Strait area between Baffin Island and Greenland (Northwest Atlantic Fisheries Organization (NAFO) Subareas (SA) 0+1) has been the location of a number of important groundfish fisheries since the late 1960's. Research cruises to SA 0+1 were carried out by Canada in the 1958-73 period although the coverage was not complete (Parsons, 1976). The French vessel *Cryos* surveyed SA 0 in 1977 as far north as 66°30'N (Forest *et al.*, 1978). A similar survey was conducted, in 1978, by the Federal Republic of Germany but only in depths less than 300 m (Atkinson *et al*, 1982). Since 1978, the Soviet Union has been conducting annual surveys in SA 0 (see for example Chumakov and Borovkov, 1986) primarily concerned with determining biomass estimates of Greenland halibut. A number of surveys have also been conducted in SA 1 with various objectives and target species (see for example Smidt, 1969; Lehmann, 1986; and Messtorff, 1986). These surveys covered limited areas and hence, very little was determined concerning the overall distribution and abundance of the various groundfish species throughout the entire Davis Strait area.

In 1986, the Newfoundland Region of the Department of Fisheries and Oceans mounted an extensive cruise to survey the ice-free area of SA 0+1 in depths of 200-1250 m from about Cape Chidley in the south (61° N) to Disko Island in the north (70° N). This paper describes the distribution of five major species of groundfish caught during this survey: Greenland halibut (*Reinhardtius hippoglossoides* Walbaum), deepwater redfish (*Sebastes mentella* Travin), golden redfish (*S. marinus* L.), roundnose grenadier (*Coryphaenoides rupestris* Gunn.) and roughhead grenadier (*Macrourus berglax* Lacépède).

Materials and Methods

The stratified-random survey was conducted in NAFO Subareas 0+1 (Fig. 1) using the chartered research vessel *Gadus Atlantica*, an 80 m stern trawler, using a Engel 145 high rise otter trawl with 29 mm mesh liner in the codend. The area was stratified by depth zone prior to the cruise and the number of fishing stations selected in each stratum was proportional to its geographic area with an initial target of one set per each 350 square nautical miles and minimum of two sets per stratum. Additional pre-selected sets were also fished in some strata. Duration of the cruise was 31 days and a total of 194 successful 30 minute tows were made in depths of 200-1250 m. Bottom temperature was determined at each fishing station using expendable bathythermographs (XBT's).

Catches were separated by species then weighed. For each species, depending on the size of the catch, the entire catch or a subsample was measured (lengths) and various other sampling carried out as required (eg. otoliths collected for ageing, stomach contents determined, gonad maturity stage determined etc. or whole fish were frozen for further analysis back in the laboratory). Redfish were spot checked for species identification by dissection of the extrinsic gasbladder musculature (Ni, 1981; Power and Ni, 1982).

The overall abundance and biomass of Greenland halibut (*Reinhardtius hippoglossoides* Walbaum), deepwater redfish (*Sebastes mentella* Travin), golden redfish (*S. marinus* L.), roundnose grenadier (*Coryphaenoides rupestris* Gunn.) and roughhead grenadier (*Macrourus berglax* Lacépède) were determined (no Acadian redfish, *S. fasciatus*, were found during the survey). The distributions of the species were expressed as the average numbers and weights caught per 30 min. tow by unit areas of 30' latitude and 1° longitude. In addition, the distributions (number and weight) by 100 m depth intervals (200-299 m, 300-399 m, 400-499 m, 500-599 m, 600-699 m, 700-799 m, 800-899 m, 900-999 m, 1000-1099 m and >1099 m) and 1°C temperature intervals (<-1.0°C, -1.0 to -0.1°C, 0.0 to 0.9°C, 1.0 to 1.9°C, 2.0 to 2.9°C, 3.0 to 3.9°C, 4.0 to 4.9°C and >4.9°C) were determined. The average temperature for each depth range was also calculated. The mean weights of the species per depth interval were examined to check for indications of stratified size distribution according to depth.

Length frequencies were combined to obtain an overall indication of the population structure of each of the species. In addition, the length distributions of the fish in each depth range were compared to examine for length stratification with depth.

Results and Discussion

The distribution of sets (Fig. 2 and 3) indicates that the area was well covered both geographically and by depth. Since the number of fishing stations increased with stratum area, the distribution of sets with depth and temperature range gives an indication of the proportion of each range present in the Davis Strait area. About 50% of the area has depths of <500 m. During the survey, 30% of the sets were made in water temperatures between 3.0 and 3.9°C.

There appears to be a gradual increase in mean temperature as the depth increases (Fig. 4) although the confidence intervals are quite wide indicating considerable variability within any one depth range. The variability observed may be attributed to the wide area of sampling. It is known that the water is generally cooler on the Canadian side of Davis Strait. There may also be a temperature gradient from north to south but this was not examined.

Greenland halibut

Greenland halibut were caught throughout the range of the survey (Fig. 5). The mean numbers per tow were about the same up to depths of 599 m (Fig. 6a), however, the mean numbers per tow began to increase from a depth of 600 m to maximize at a depth range of 900-1000 m beyond which the mean numbers per tow declined. The mean weight per tow showed a relatively similar pattern except that the increasing trend was more obvious (Fig. 6b). With the exception of the 500-599 m depth interval there is a clear increasing trend in mean fish weight per tow (Fig.7) up to the maximum depth interval surveyed. Greenland halibut were caught throughout all temperature ranges encountered from <-1.0 to 5.0°C (Fig. 8). However, it appeared that temperatures beyond 1.0°C were preferred and the greatest numbers were caught at 1.0-1.9°C.

The distribution patterns shown here are not particularly different from those presented by Bowering (1984) for the Labrador and eastern Newfoundland area. However, Greenland halibut in this area appeared to be more abundant at higher temperatures than those of the Davis Strait region. The distribution patterns here are quite different than those shown from surveys conducted in the winter by the USSR (Bowering and Chumakov, In preparation). These surveys indicate that large mature Greenland halibut are found in high abundance in the southern region of Davis Strait at depths of 1300-1500 m where spawning takes place. During the time of year when the present survey was conducted it is likely that many fish are in the deepwater fjords of West Greenland.

Length frequency distributions of Greenland halibut by depth range are shown in figure 9. Overall, the lengths of Greenland halibut caught ranged from 8 cm to 110 cm (Fig. 10). Length compositions for the 200-299 m and 300-399 m depth ranges were similar with a high incidence of small fish having a mode of 12.5 cm. The length composition in the 400-499 m depth range had very few of these small fish represented with most fish occurring in the 20-40 cm length range. In the 500-599 m depth range most fish were the 30-60 cm length range. For depths greater than 500 m there were very few fish less than 40 cm caught with most fish occurring in the 40-60 cm length range.

Similar variations in size compositions over depth have also been reported by Bowering (1984) for the Labrador and eastern Newfoundland area, however, the transition in size classes with depth were not as clearly defined as presented here. This is partially due to the scarcity of small fish in the previous study. Also, the change in size

composition between the 400-499 m to 500-599 m range in this study was not usually apparent until reaching depths of over 700m in the study of Bowering (1984).

Total estimated minimum trawlable biomass of Greenland halibut estimated in the survey area was about 282,000 t with an associated abundance of about 311 million fish. This estimate is not considered to be an accurate reflection of the Greenland halibut biomass in the Davis Strait region since much of the resource is likely to be in the fjords of West Greenland at this time of year as previously discussed. This estimate is about one half the estimated biomass in the Labrador and eastern Newfoundland region according to Bowering and Brodie (1986) which is also considered to be a minimal estimate for that area.

Deepwater redfish

The survey results (Fig. 11) indicate that deepwater redfish are fairly widely distributed throughout the area. The greatest numbers were found in depths of 300-399 m but the greatest weights were taken in 500-599 m (Fig. 6) indicating an increase in fish size with depth (Fig. 7). The distribution of fish lengths with depth also shows this increase in size with depth (Fig. 12). This phenomenon is well known for redfish and is extensively documented in the literature (see Atkinson, 1984). The species was primarily found in water temperatures exceeding 1.9°C (Fig. 8). This finding agrees with earlier reports that the preferred temperature range is between about 2°C and 7°C (Atkinson, 1984).

Total estimated minimum trawlable biomass of deepwater redfish in the survey area was about 25,000 t with an associated abundance of about 267 million fish. The length distribution of the estimated population (Fig. 10) indicates a mode at about 18 cm. The overall mean weight of the fish in this area (0.093 kg) is less than in more southerly areas such as NAFO Divisions 2J and 3K where the mean weight is about 0.4 kg. In addition, there is an apparent cline in the size of redfish with smaller individuals predominating in the more northern areas. This phenomenon has been observed previously. Large numbers of these small fish are often encountered in the shrimp fishery between 66°N and 70°N and it has been postulated that this region may be a nursery area (Anon., 1983) although the source of the larvae is not known.

Relatively few mature fish were encountered during the survey but these were present, in small numbers, as far north as about 67°N. Of these, only one was female (46 cm and in spent condition). Most of the males were maturing for the current year but it could not be determined if this was first or repeated maturation. Ni and Sandeman (1984) reported that the size of 50% maturity (L_{50}) of this species is greater in more northern areas of the Northwest Atlantic, and the results of this survey confirm this. Whether the mature fish eventually spawn in this area or migrate south and east of Greenland first is not known but the absence of mature females might suggest the latter as has been hypothesized previously (Anon., 1983).

Golden redfish

Only small numbers of golden redfish were caught during the survey and the majority of these were taken in SA 1 (Fig. 13). The minimum trawlable biomass was estimated to be only about 3000 t with an associated abundance of about 5 million fish. They ranged in size from 15 to 61 cm (Fig. 10). None of the fish caught were sexually mature supporting the hypothesis that these fish originate south or east of Greenland (Anon., 1983). There are reports that discrete stocks of this species may exist in the fjords of Greenland (Anon., 1983).

This species of redfish was found in somewhat warmer waters than the deepwater redfish, preferring temperatures above about 3°C (Fig. 8). Most of the fish (numbers) were taken in depths of 200-399 m (Fig. 6) but the catches by weight were distributed

fairly evenly between about 200-599 m. As with the deepwater redfish, fish size increased with increasing depth (Fig. 7 and 14) but this species was generally found in shallower water than the deepwater redfish. This is similar to their relative distributions in more southerly areas (Ni and McKone, 1983).

Roundnose grenadier

This species was not caught north of about 66°30'N (Fig. 15) and predominated in SA 1. The overall distribution agrees fairly well with the assumed area of the commercial fishery postulated by Atkinson *et al.* (1982). The minimum trawlable biomass was estimated to be about 111,000 t representing about 445 million fish. They were found in depths ranging from about 700 m to >1099 m with the largest catches (both numbers and weights) being taken in the 900-999 m range (Fig. 6). There was a gradual increase in fish size with depth (Fig. 7 and 16). The fish were found in water temperatures ranging from 3.0-4.9°C (Fig. 8) similar to the fairly narrow range preference described by Parsons (1976).

Only a few fish were found to be mature or maturing and these were all male. Similar findings have been reported from more southern areas of the Northwest Atlantic. It is believed that sexually mature fish occur in greater depths (1470-1520 m) (Savvatimskii, 1972) than those covered by this survey and that spawning occurs in mid-April (Geistdoerfer, 1979). The apparent decrease in abundance beyond about 1000 m, however, would tend to suggest some alternate hypothesis such as larval drift from Icelandic waters (Zakharov and Mokanu, 1970) unless there is only a relatively small proportion of the total population contributing to the spawning stock biomass in this area or catchability of the trawl decreased with depth.

The overall length distribution (Fig. 10) shows a mode (anal fin length) of about 10.5 cm. This compares well with a mode of about 11 cm reported by Borrmann(1977) but is slightly less than 13 cm for roundnose grenadier in NAFO Div. 2J3K (unpublished 1986 data).

Roughhead grenadier

Roughhead grenadier were widely distributed, in small numbers, throughout the survey area (Fig. 17). The abundance, however, decreased with increase in latitude. They were distributed over a wide range of depths (Fig. 6), a fact also noted by Parsons (1976) but were most abundant in about 700-799 m. There did not appear to be a great trend in fish size with depth (Fig. 7 and 18) but somewhat larger fish were caught below about 800 m. The occurrence of slightly larger fish in the 200-399 m range (compared to the 200-799 m range overall) agrees with the findings of Parsons (1976).

The roughhead grenadier were found over a wide range of temperatures although they were most abundant in water between about 1°C and 4.9°C (Fig. 8). Parsons (1976) reported that this species was caught in quantity between 1°C and 4°C but was most abundant in the range of 2-3.5°C.

The biomass and abundance of this species was fairly small, being only about 7500 t and about 18 million animals. The modal length (anal fin) of the population is about 14-16 cm (Fig. 10).

Very few mature fish were found, and most of these were males. There were, however, a few mature females caught and some of these had apparently spawned earlier in the year. Geistdoerfer (1979) considered this species to have a well defined spawning period and proposed late spring spawning for fish off Labrador and Iceland. Eliassen and Falk-Petersen (1985) found that peak spawning off Norway occurs in midwinter (January).

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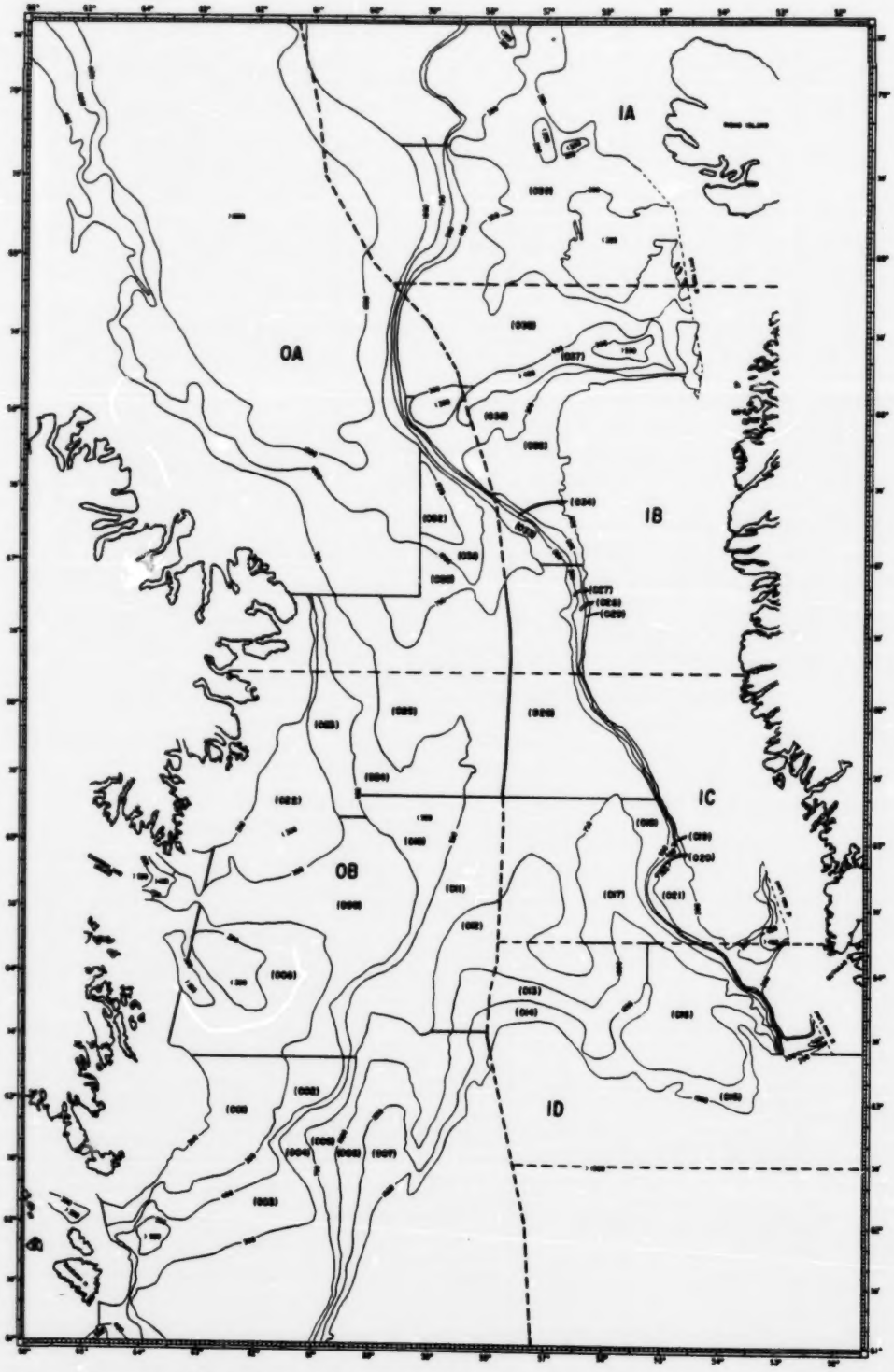

Figure 1: Davis Strait (NAFO Subareas 0+1) showing the stratification scheme used for the stratified random bottom trawl survey conducted in 1986.

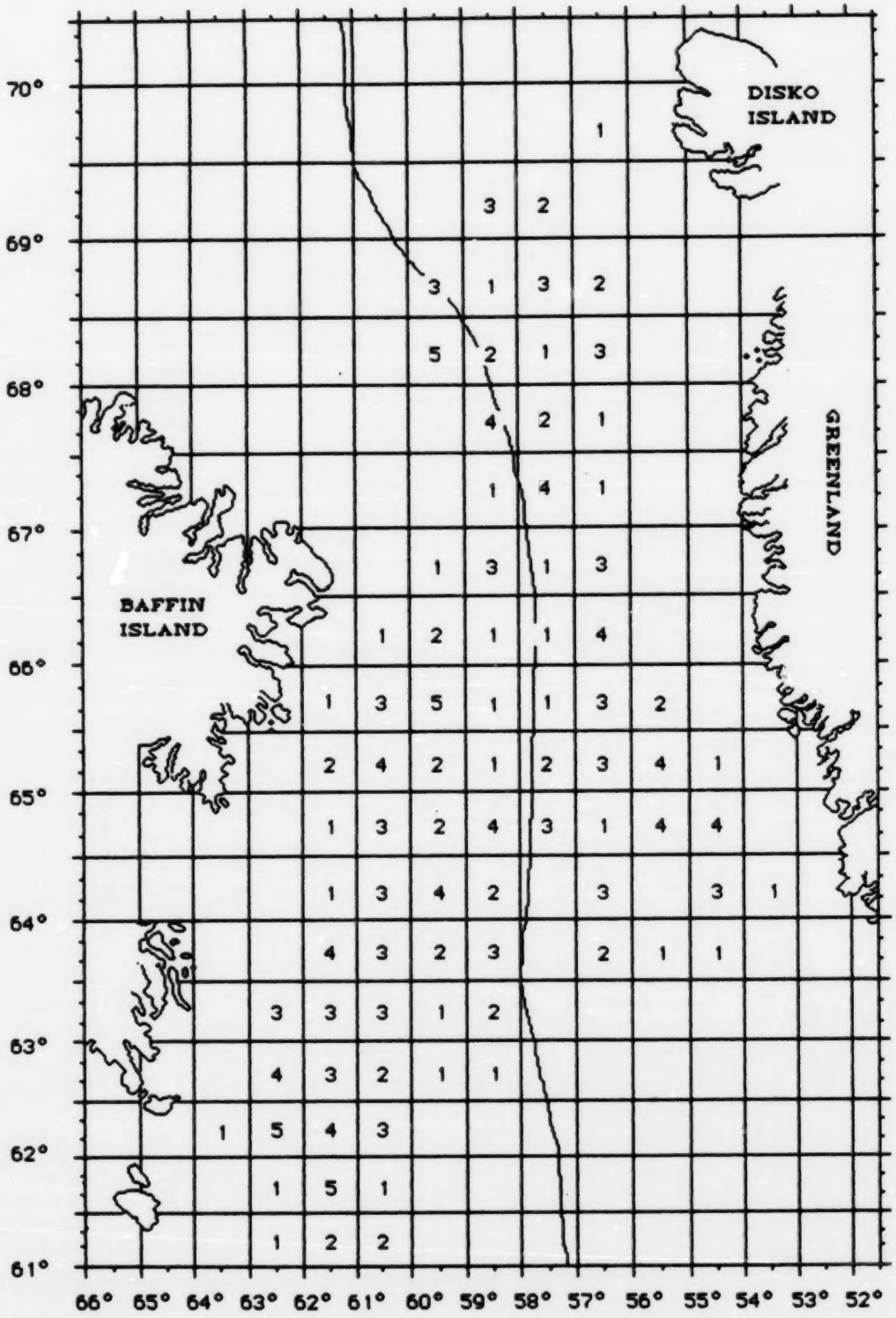

Figure 2: Map of the Davis Strait area showing the Canada/Greenland Boundary as well as the number of successful sets per Unit Area during the 1986 Canadian groundfish survey to the area.

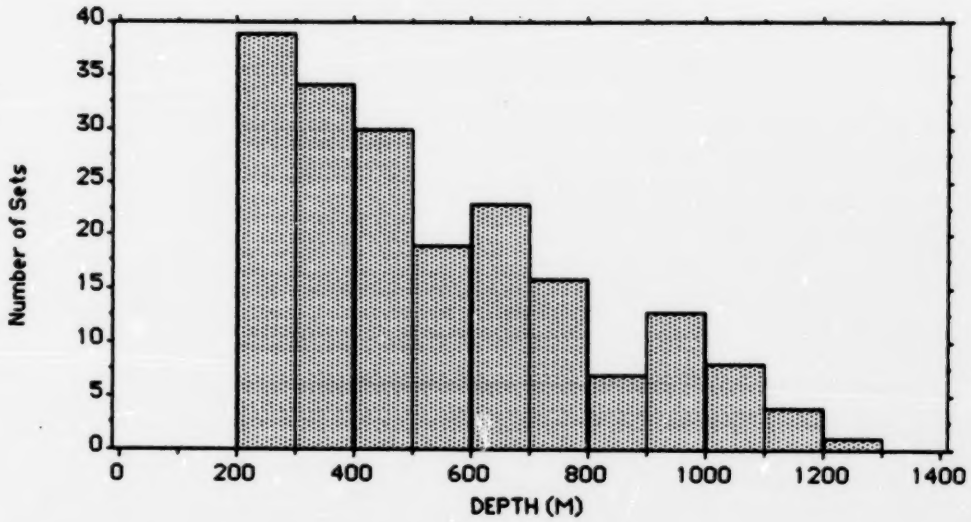

Figure 3a: Distribution of successful sets by depth range during Canadian research survey to NAFO Subareas 0+1 in 1986.

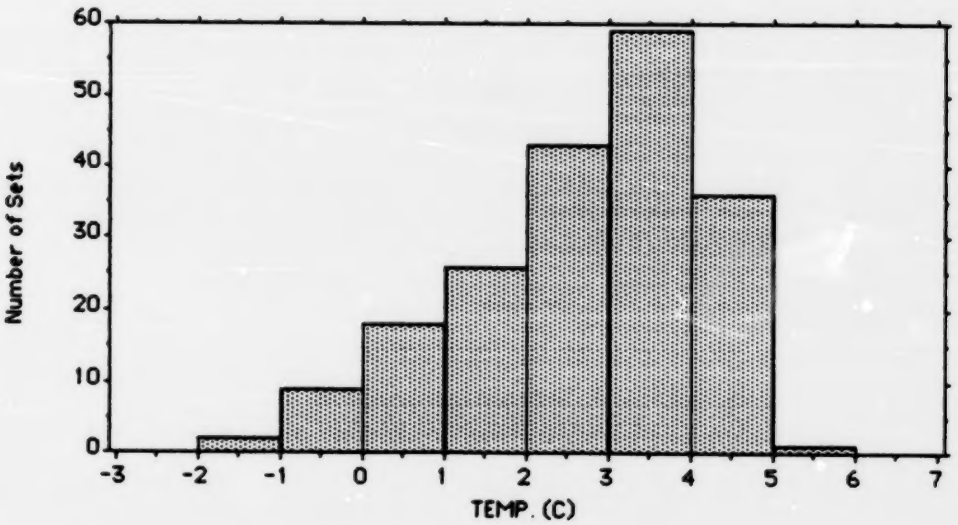

Figure 3b: Distribution of successful sets by temperature range during Canadian research survey to NAFO Subareas 0+1 in 1986.

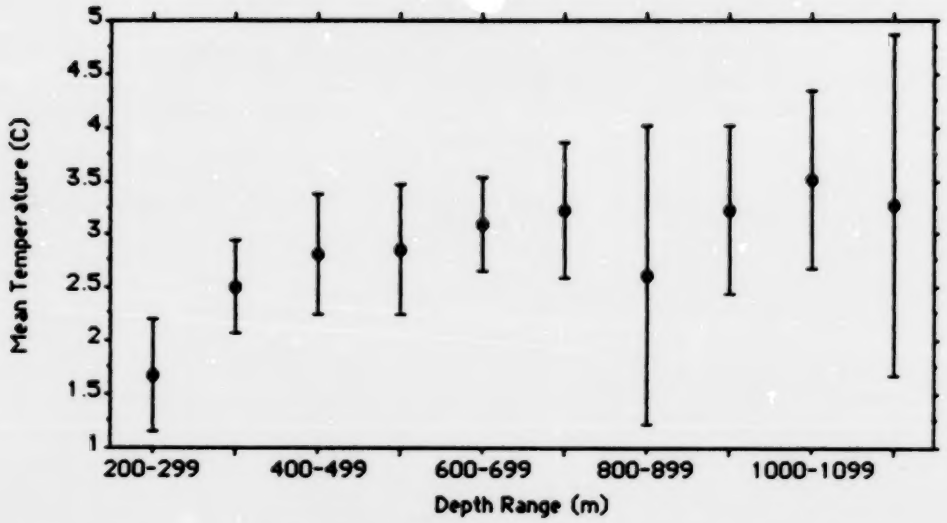

Figure 4: Mean temperatures with 95% confidence interval for the various depth ranges examined from data collected during Canadian research cruise to NAFO Subarea 0+1 in 1986.

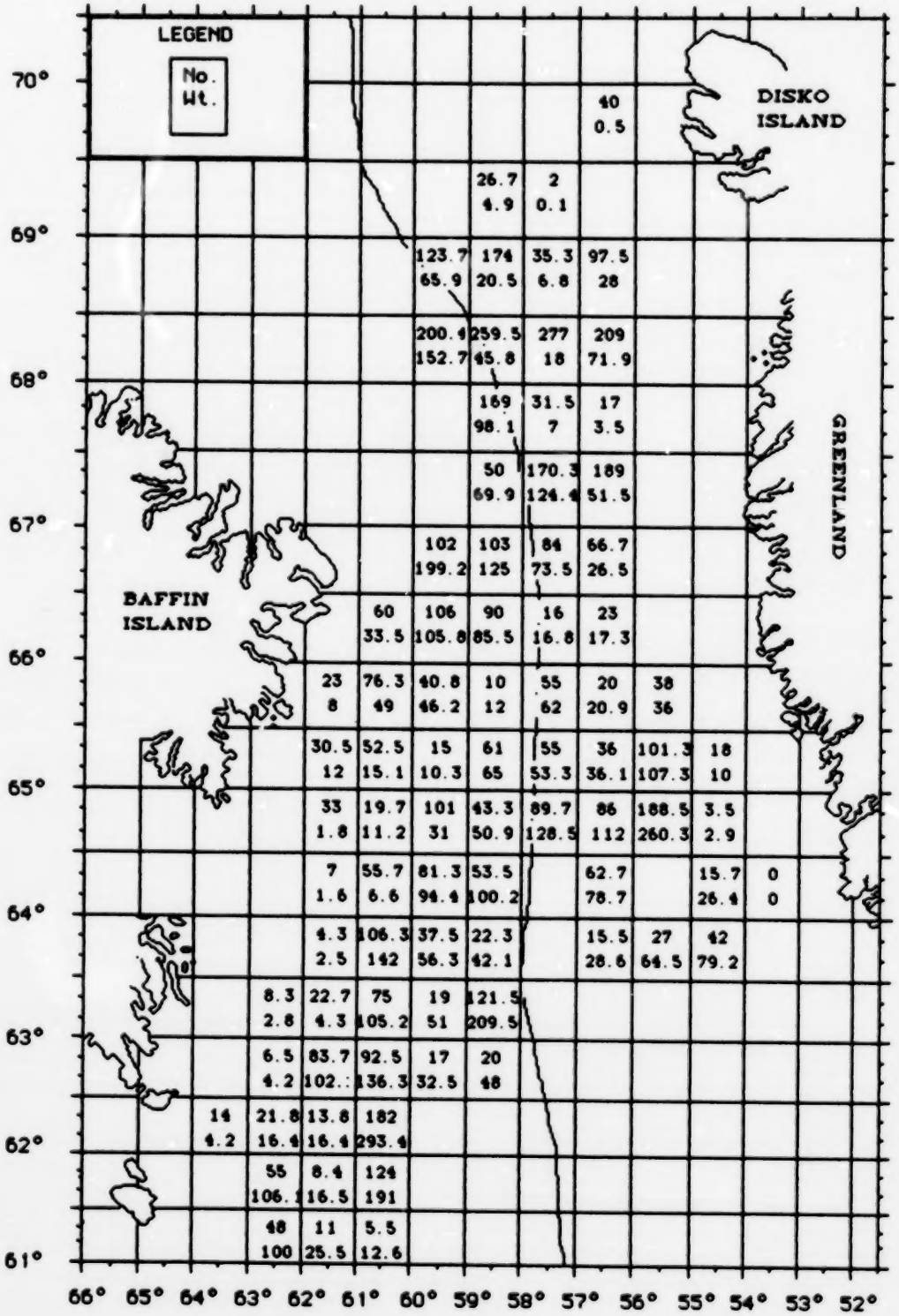

Figure 5: Distribution of Greenland halibut by Unit Area in NAFO Subareas 0+1 during Canadian bottom trawl survey in 1986.

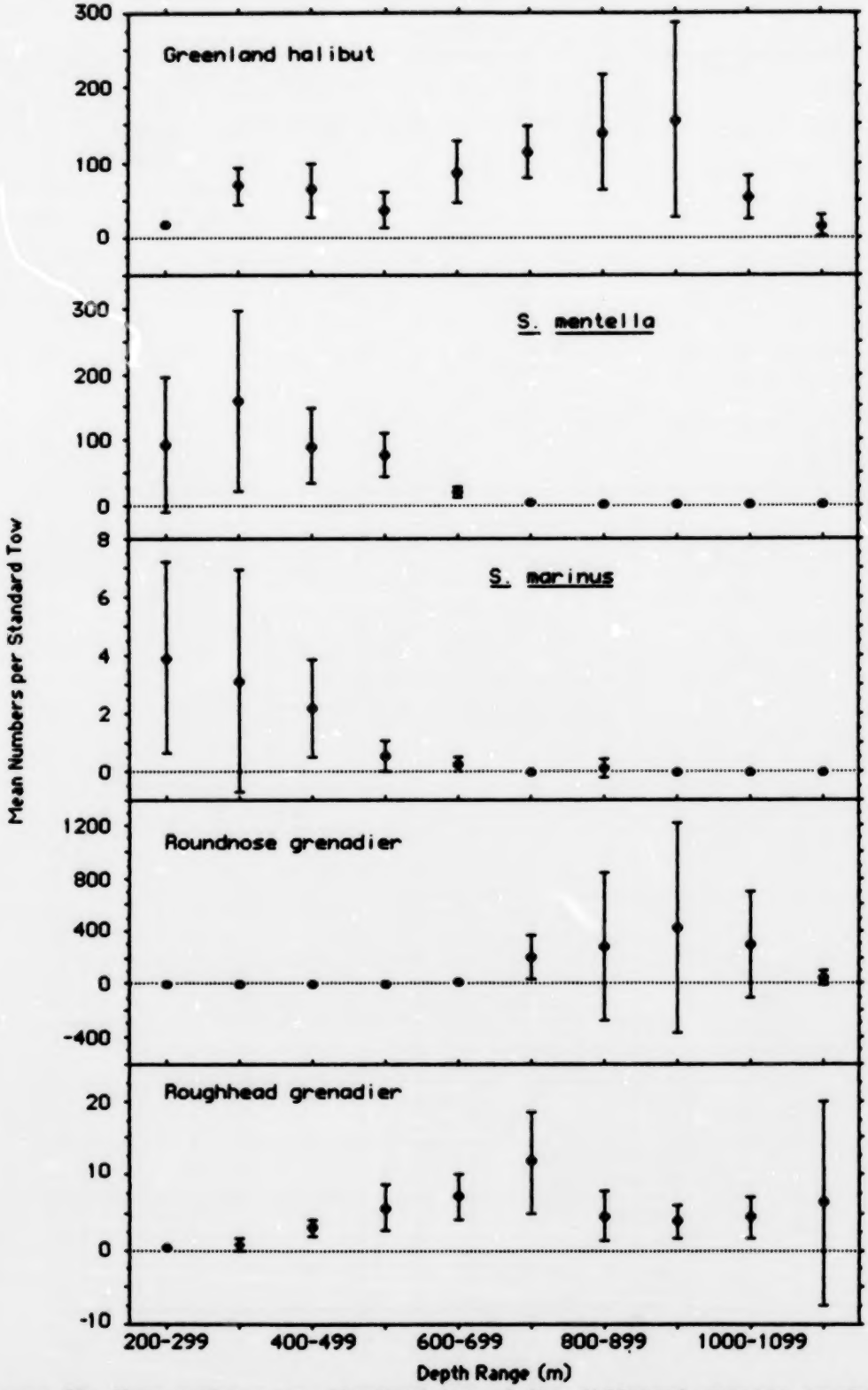

Figure 6a: Mean numbers per standard tow of the different species caught in each depth range during Canadian research survey in NAFO Subareas 0+1 in 1986 showing the 95% confidence intervals.

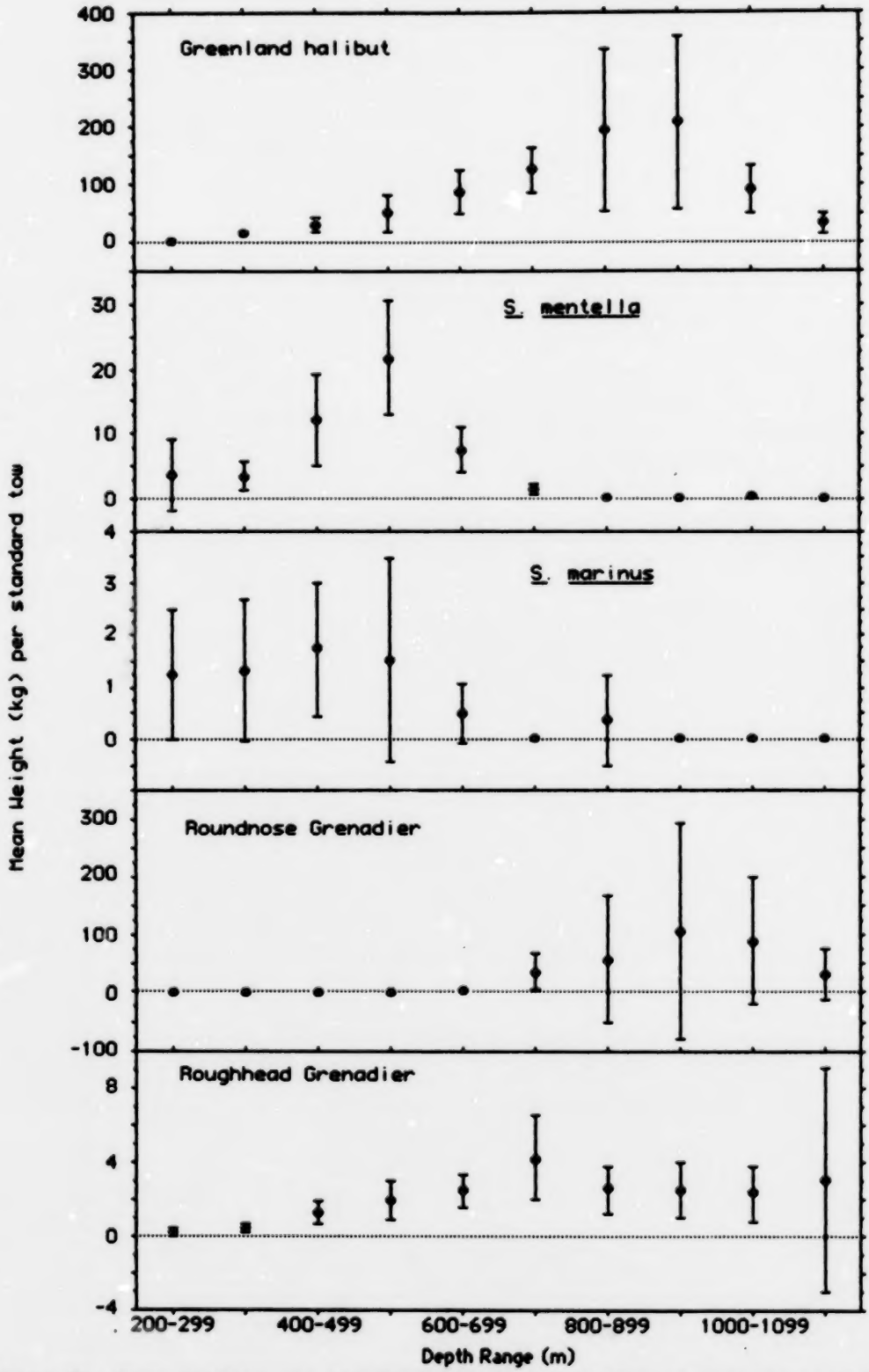

Figure 6b: Mean weights per standard tow of the different species caught in each depth range during Canadian research survey in NAFO Subareas 0+1 in 1986 showing the 95% confidence intervals.

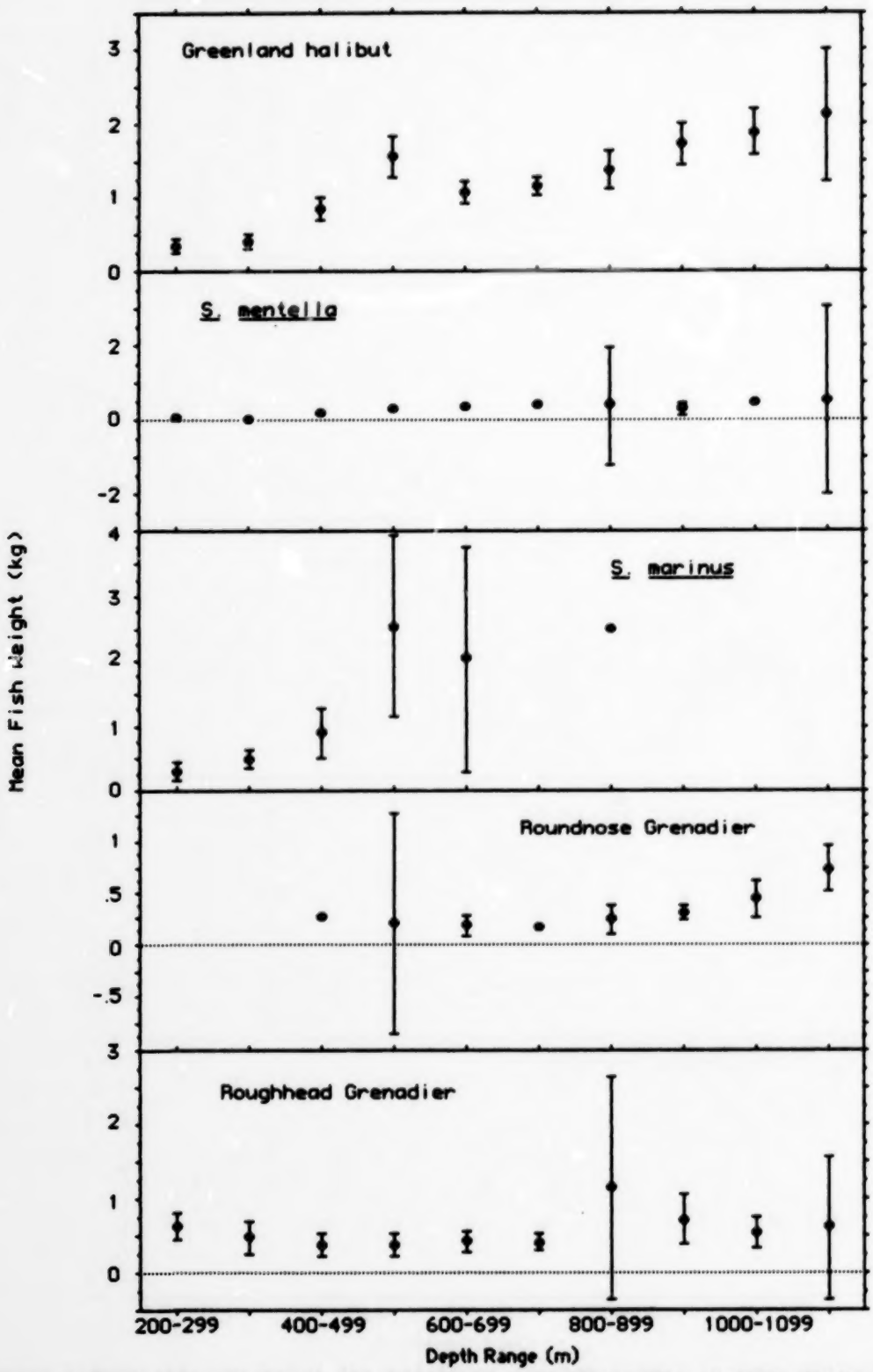

Figure 7: Mean fish weight of the different species caught in each depth range during Canadian research survey in NAFO Subareas 0+1 in 1986 showing the 95% confidence intervals.

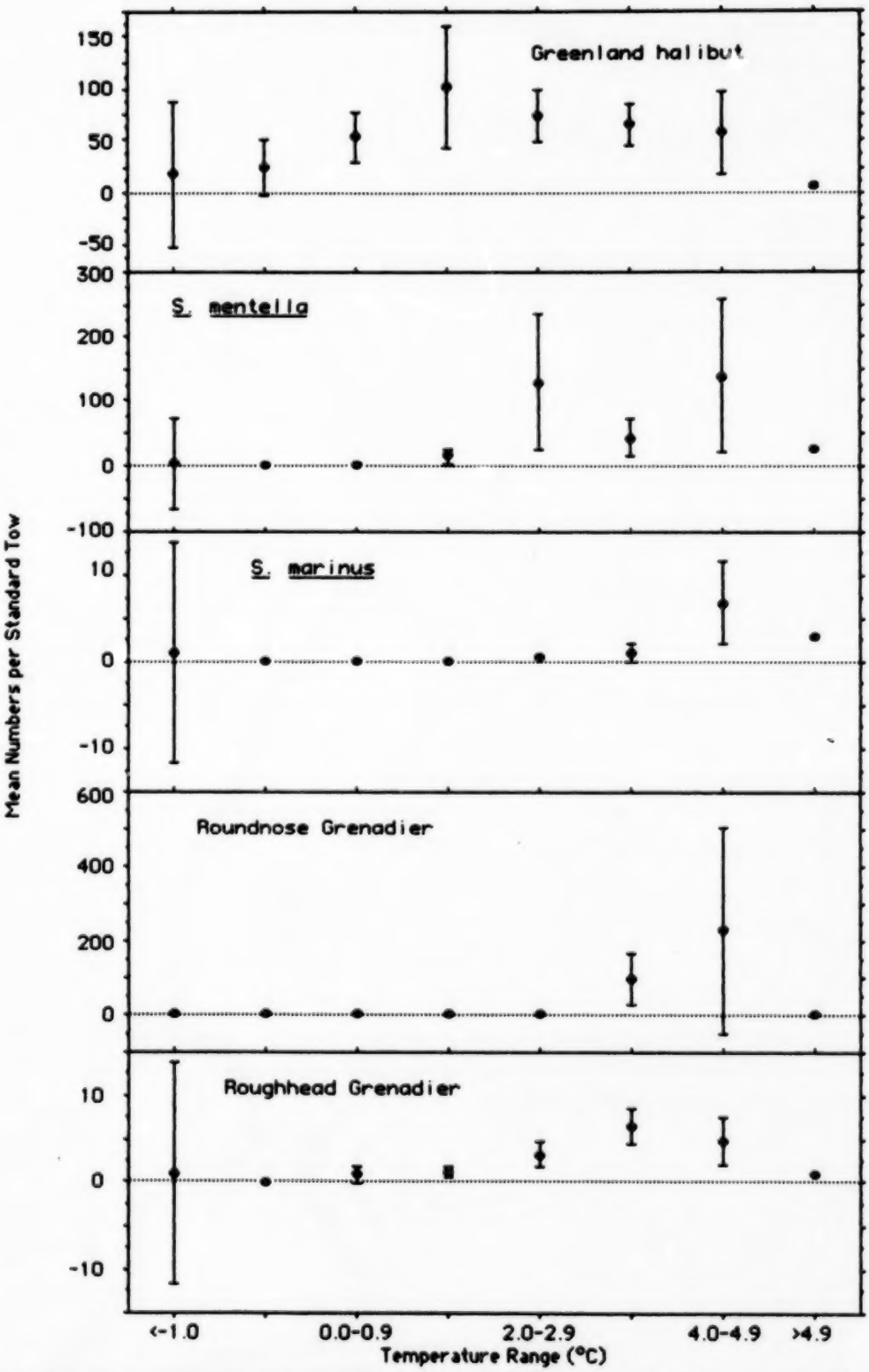

Figure 8a: Mean numbers per standard tow of the different species caught in each temperature range during Canadian research survey in NAFO Subareas 0+1 in 1986 showing the 95% confidence intervals.

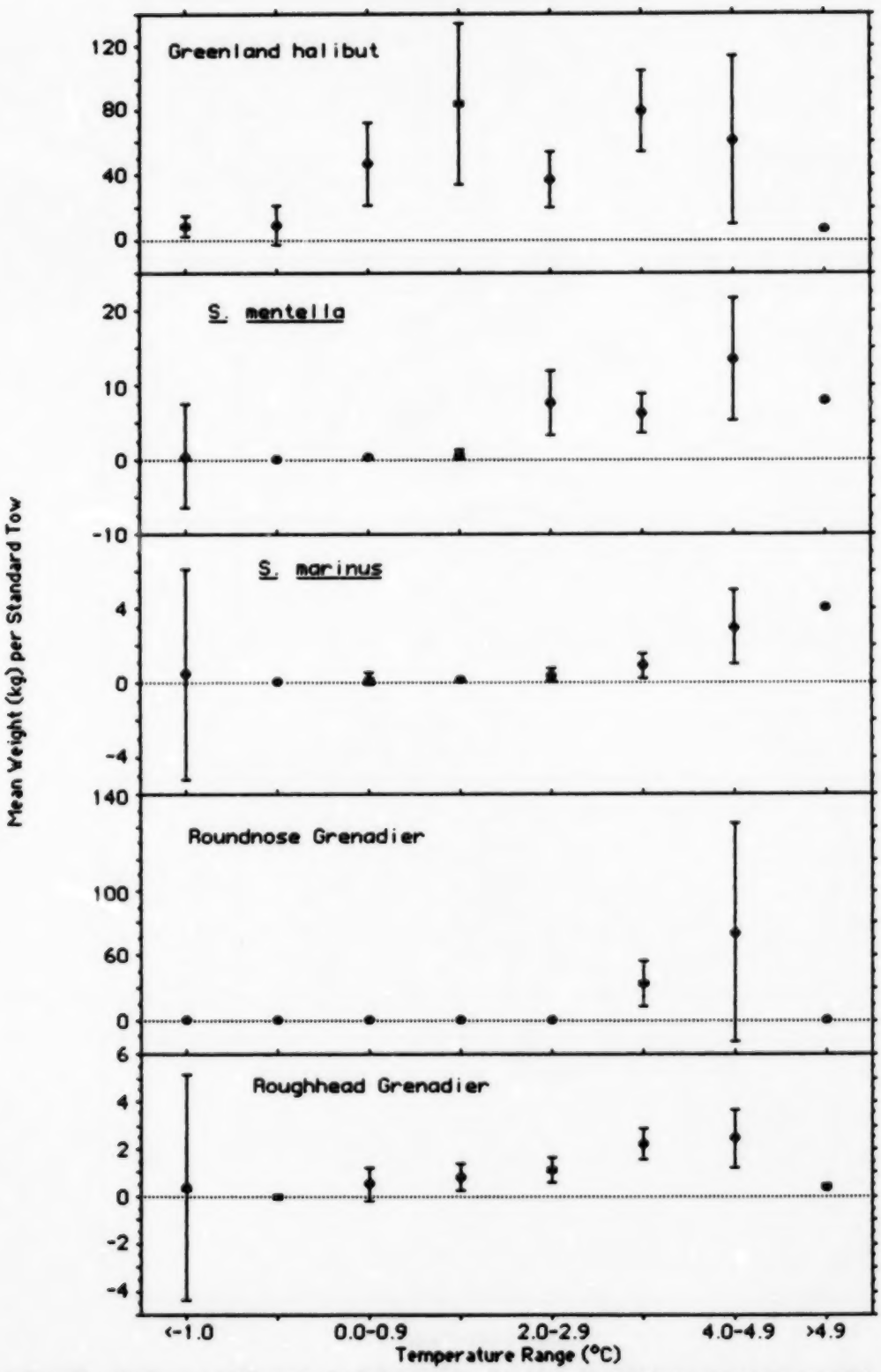

Figure 8b: Mean weights per standard tow of the different species caught in each temperature range during Canadian research survey in NAFO Subareas 0+1 in 1986 showing the 95% confidence intervals.

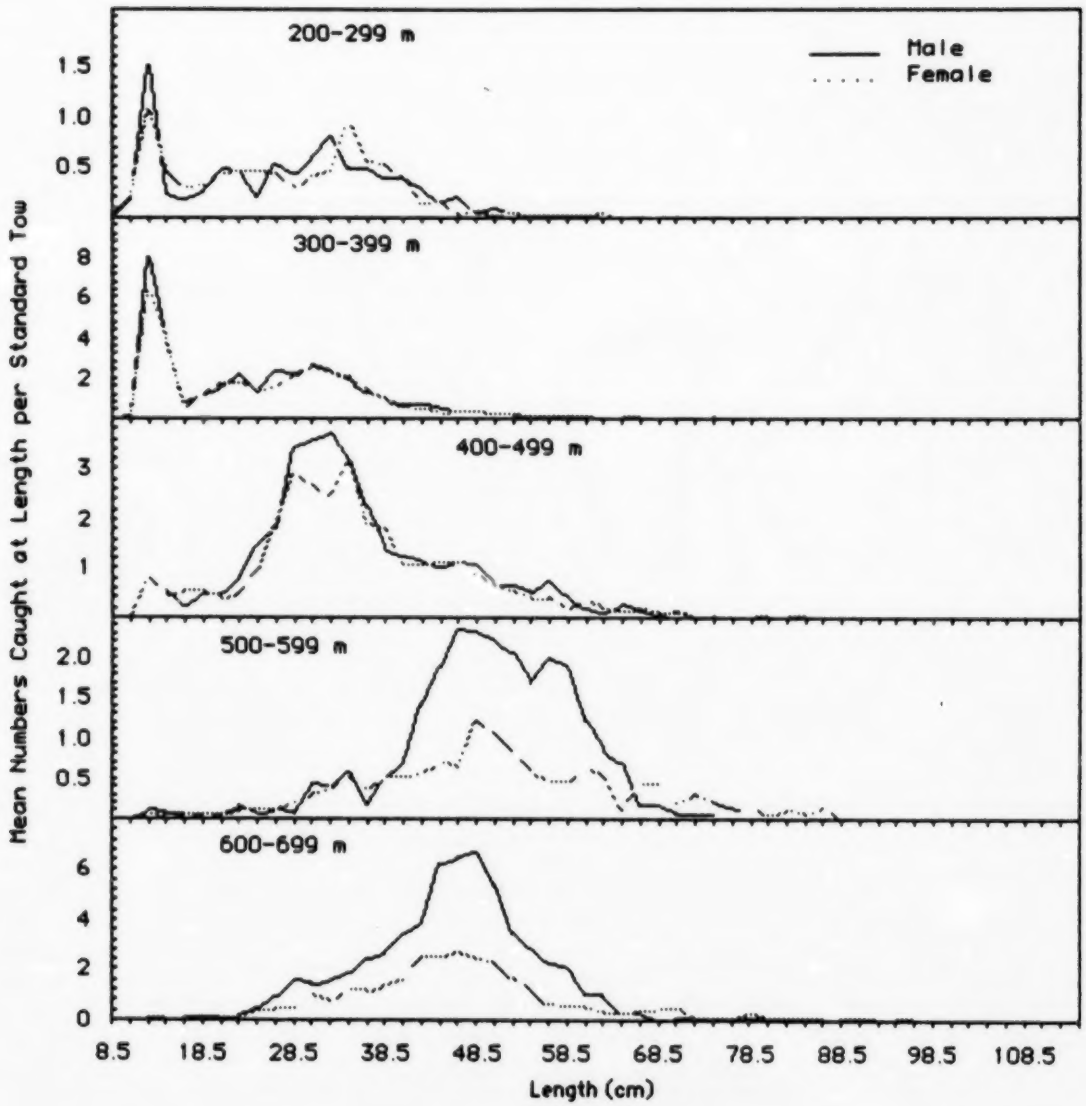

Figure 9: Mean numbers of Greenland halibut caught per standard tow by depth range during Canadian bottom trawl survey to NAFO SA 0+1 in 1986.

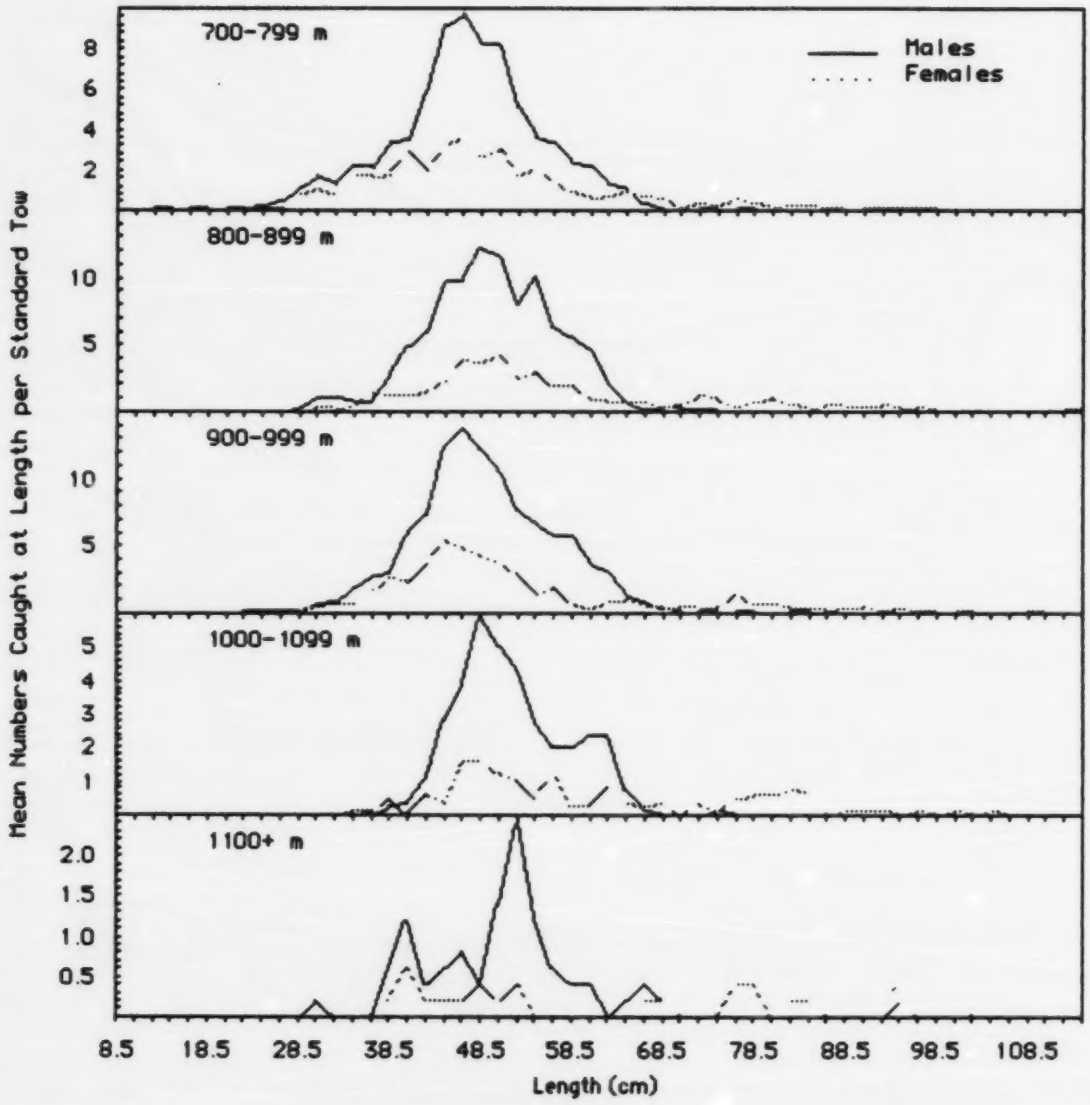

Figure 9: Continued.

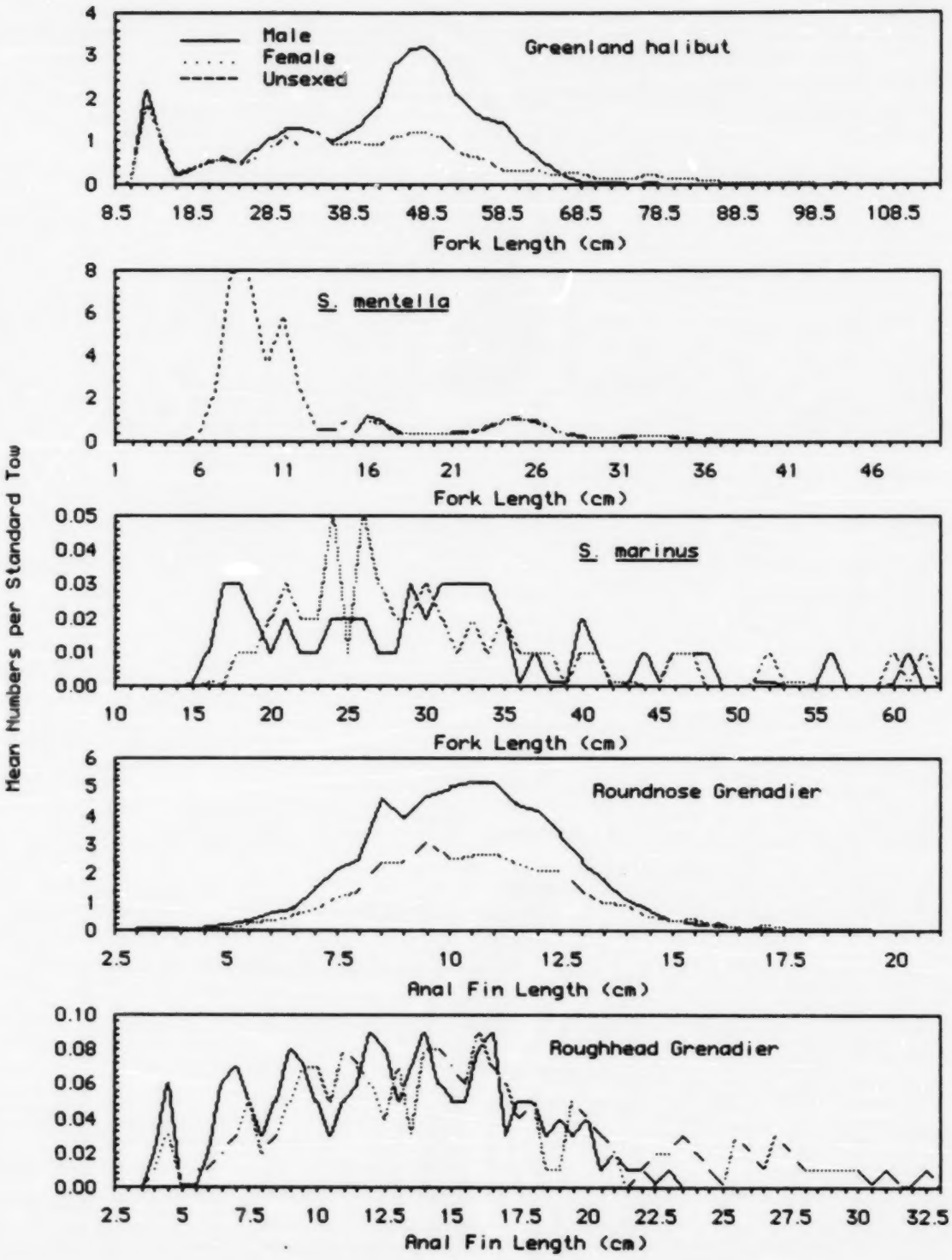

Fig. 10: Weighted mean numbers caught per tow at length during Canadian research cruise to NAFO SA 0+1 in 1986.

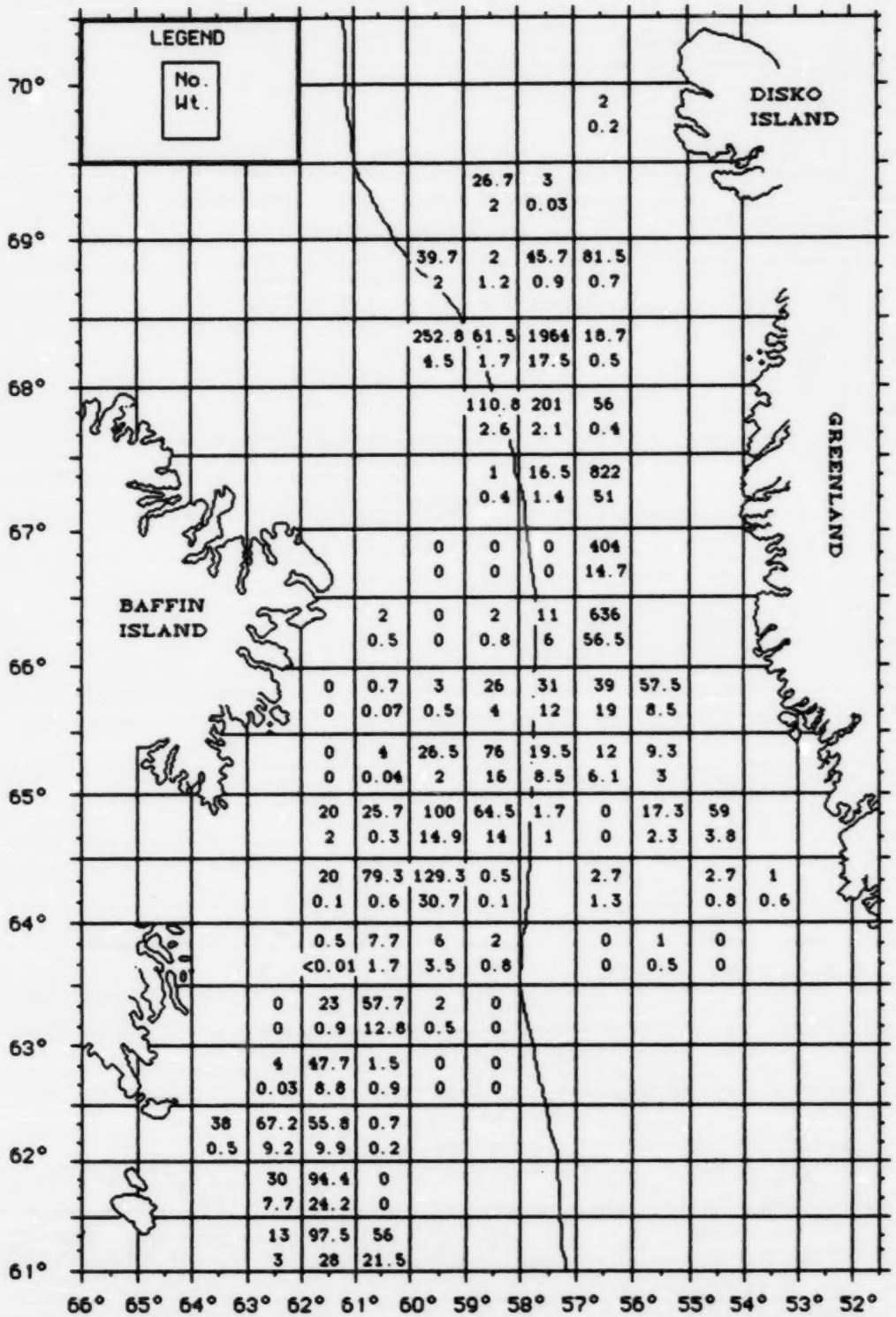

Figure 11: Distribution of S. mentella by Unit Area in NAFO Subareas 0+1 during Canadian bottom trawl survey in 1986.

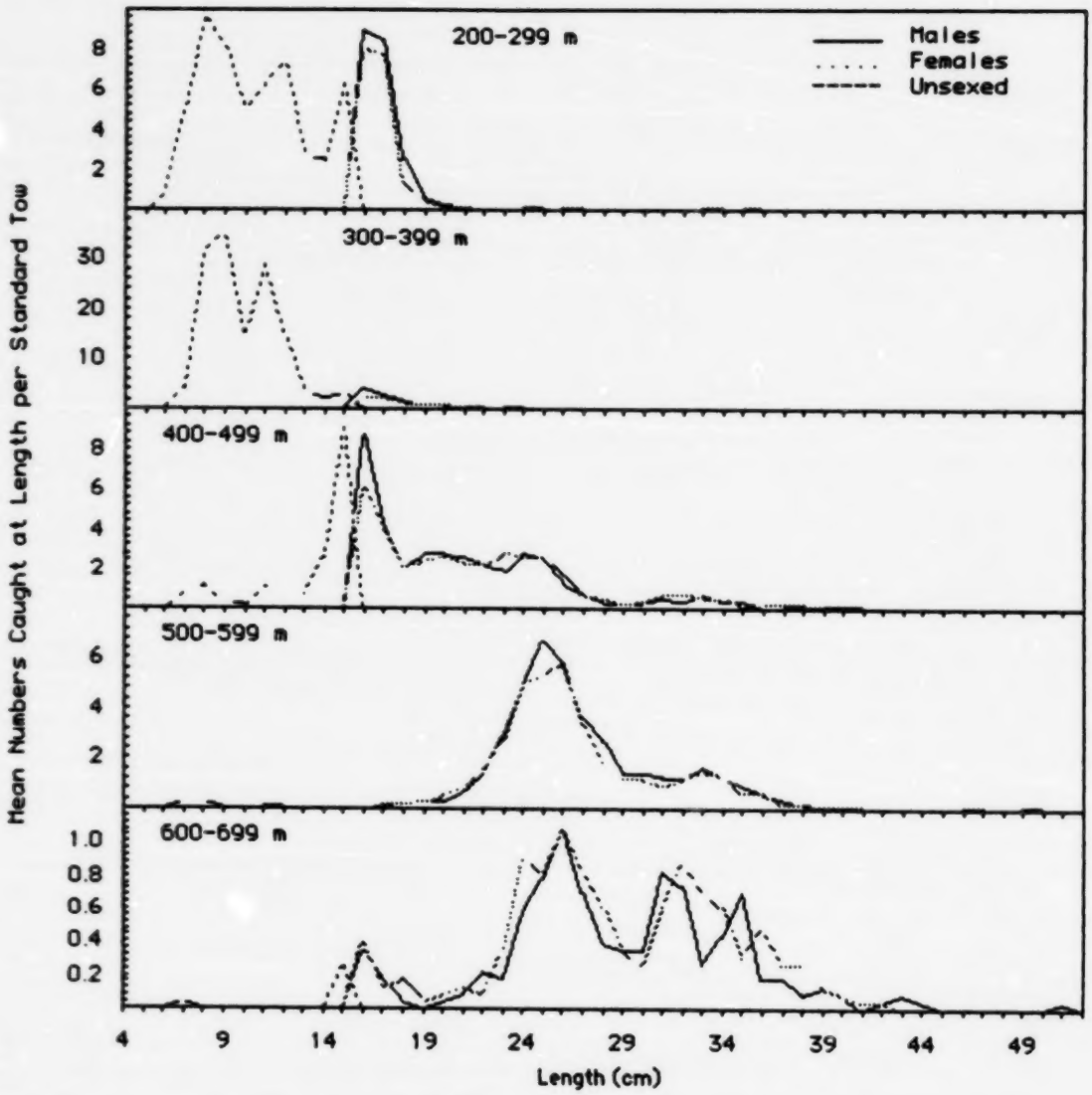

Figure 12: Mean numbers of S. mentella caught per standard tow by depth range during Canadian bottom trawl survey to NAFO SA 0+1 in 1986.

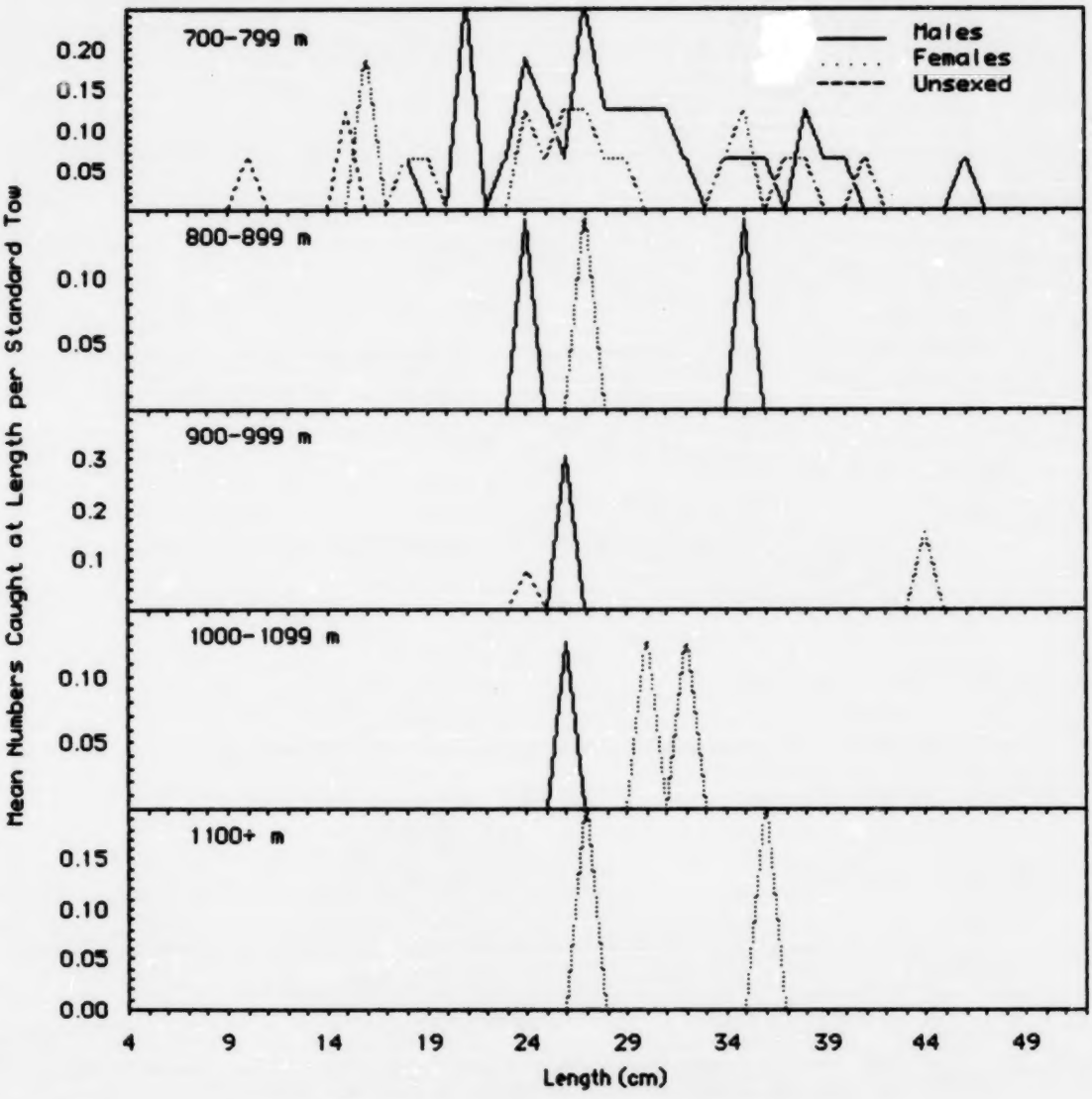

Figure 12: Continued.

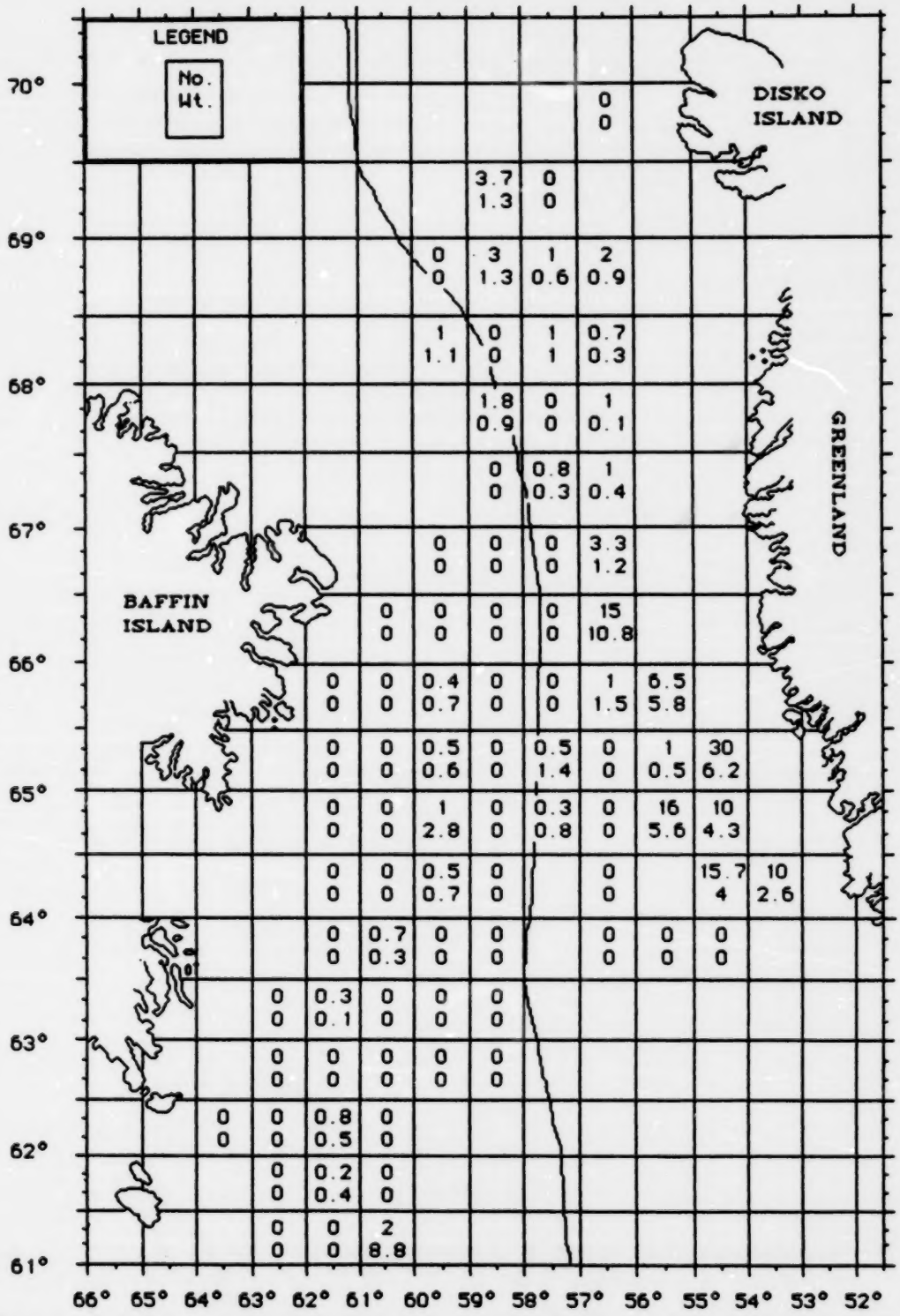

Figure 13: Distribution of S. marinus by Unit Area in NAFO Subareas 0+1 during Canadian bottom trawl survey in 1986.

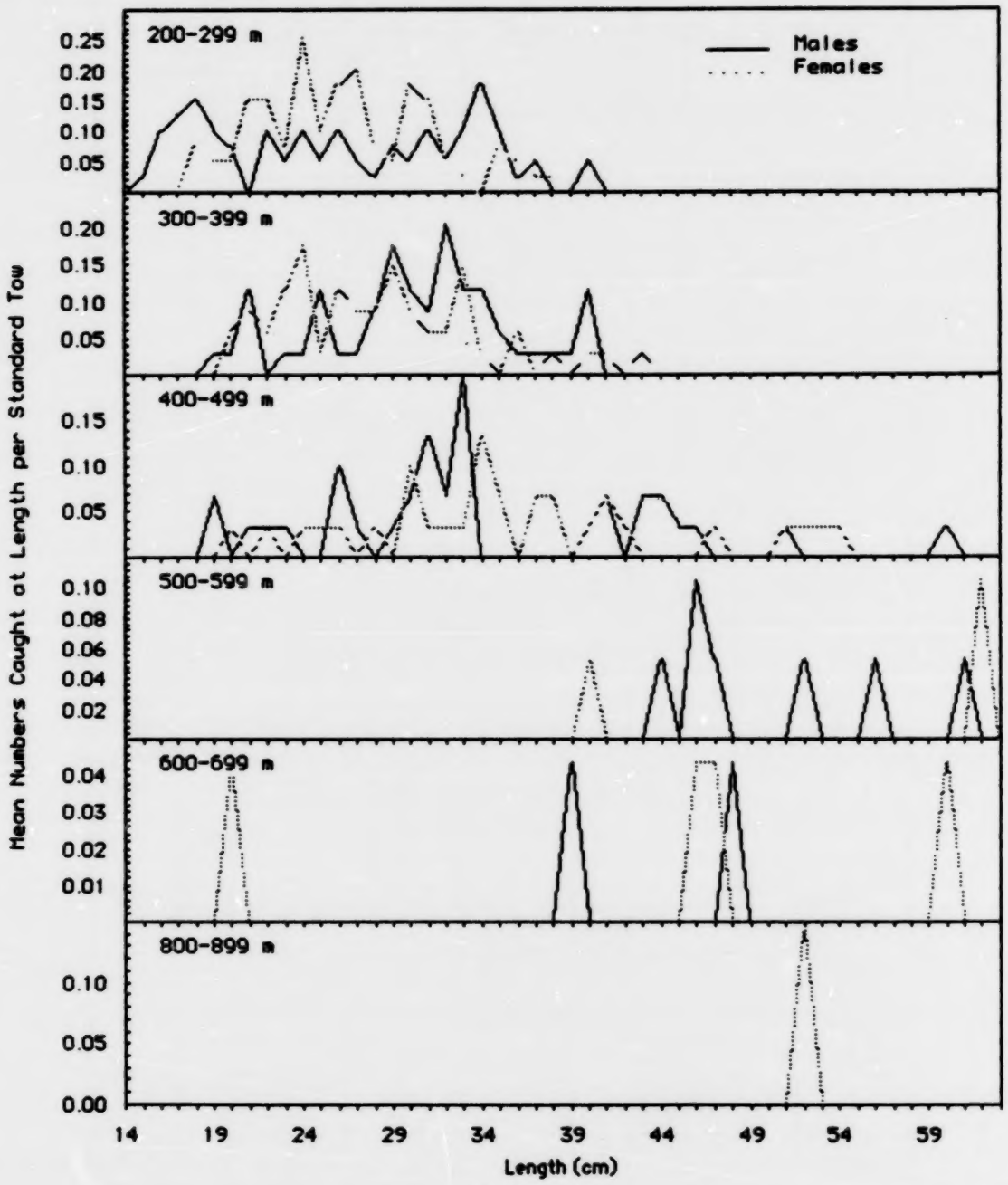

Figure 14: Mean numbers of S. marinus caught per standard tow by depth range during Canadian bottom trawl survey to NAFO SA 0+1 in 1986.

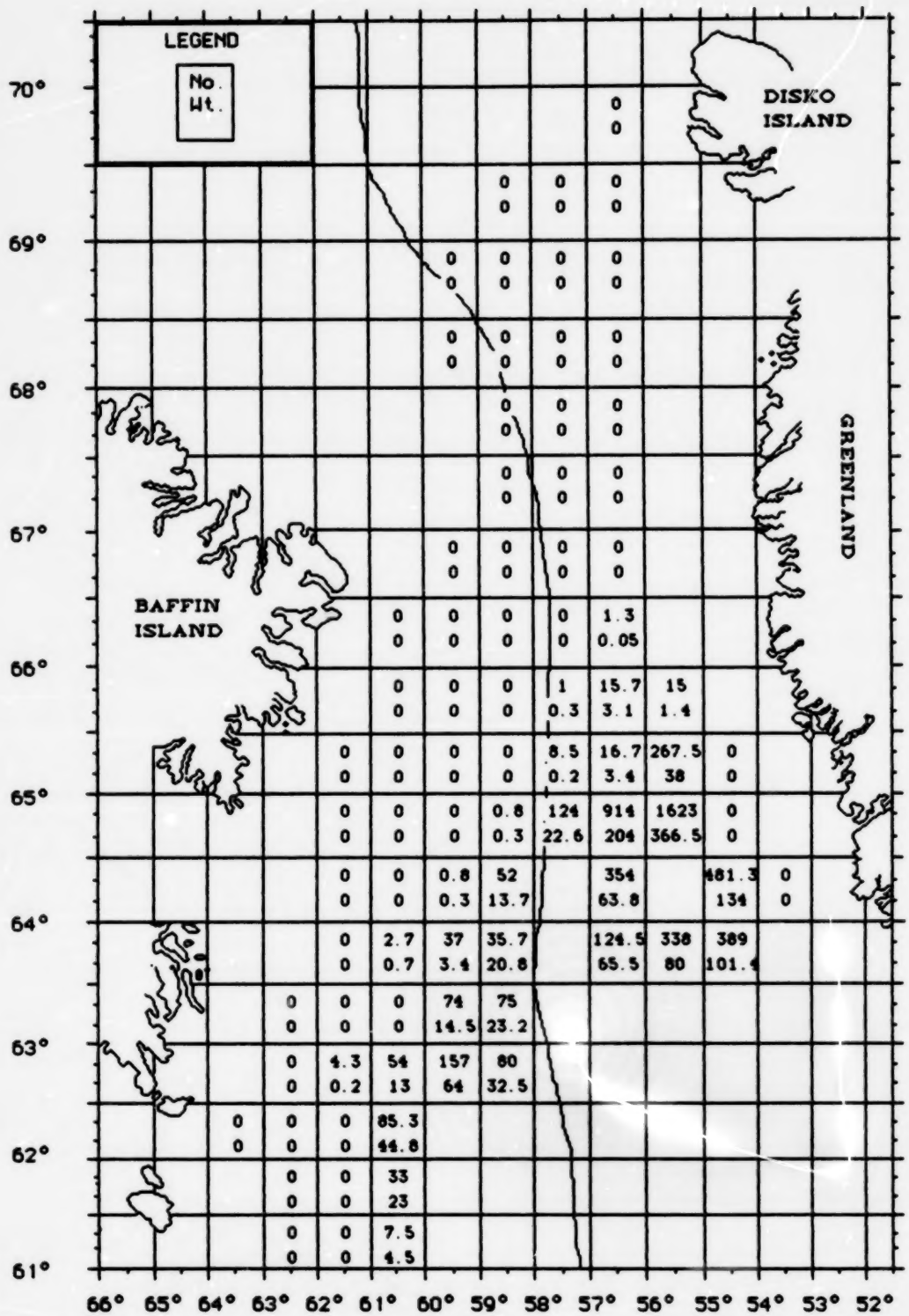

Figure 15: Distribution of roundnose grenadier by Unit Area in NAFO Subareas 0+1 during Canadian bottom trawl survey in 1986.

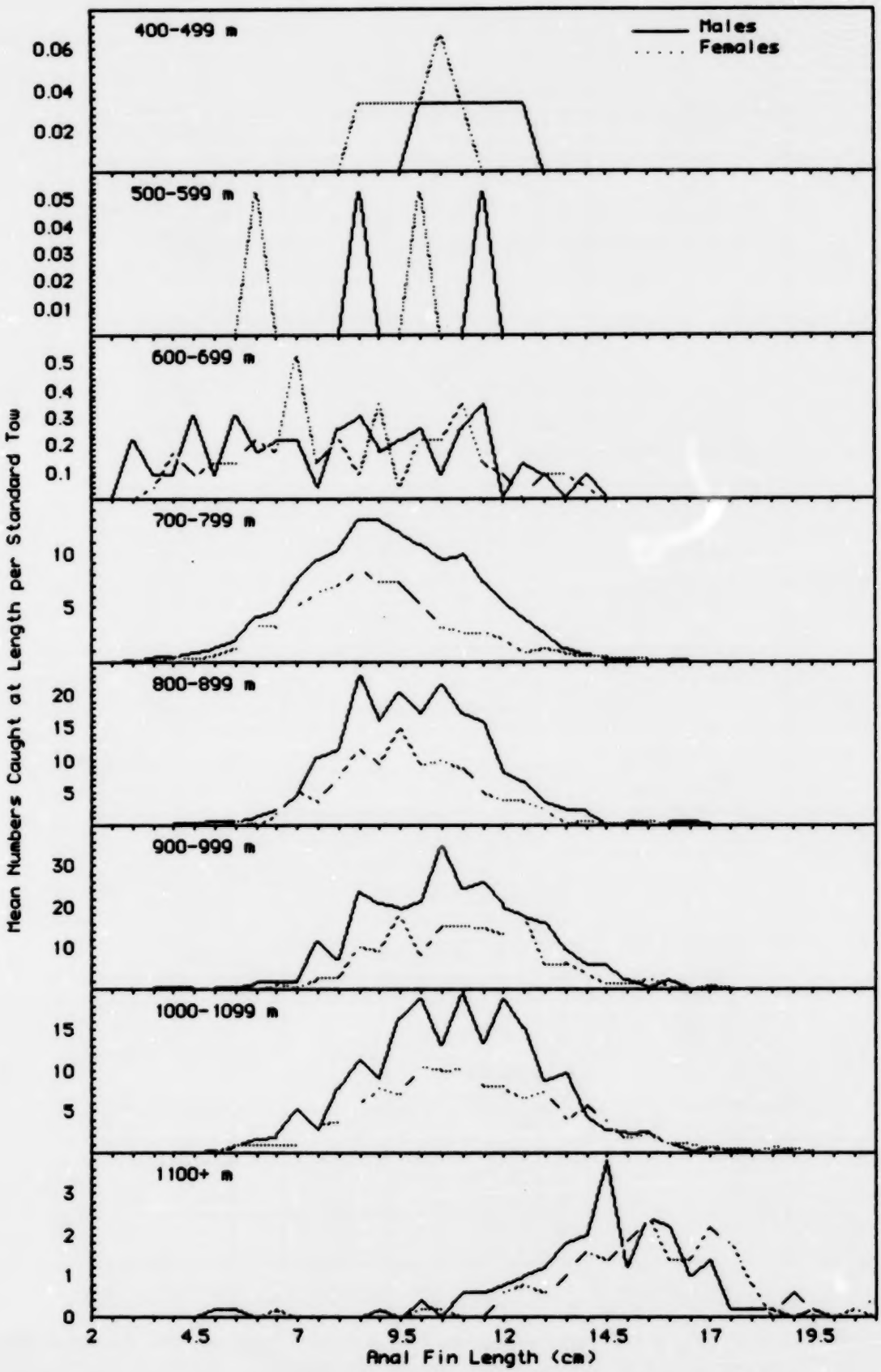

Figure 16: Mean numbers of roundnose grenadier caught per standard tow by depth range during Canadian bottom trawl survey to NAFO SA 0+1 in 1986.

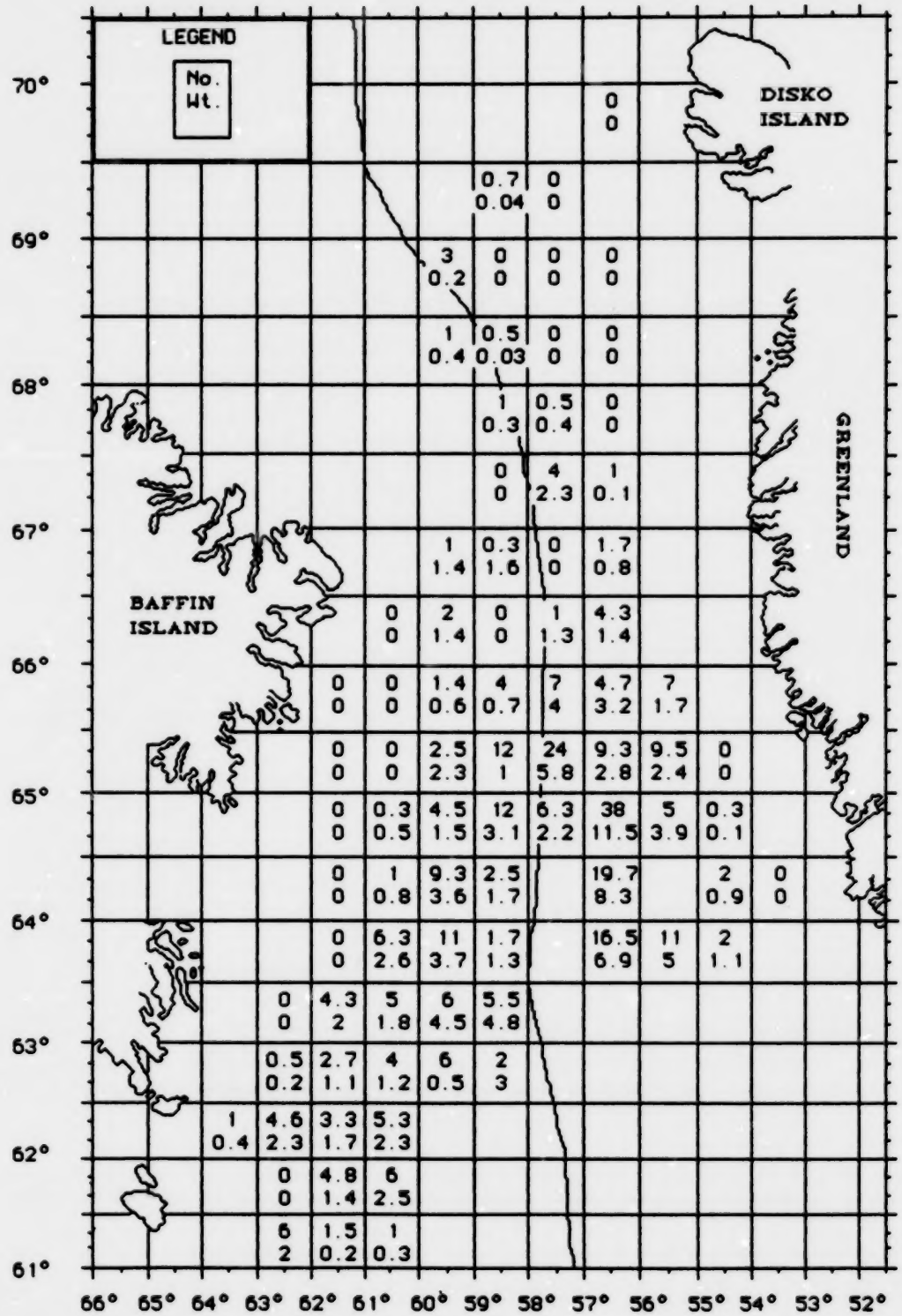

Figure 17: Distribution of roughhead grenadier by Unit Area in NAFO Subareas 0+1 during Canadian bottom trawl survey in 1986.

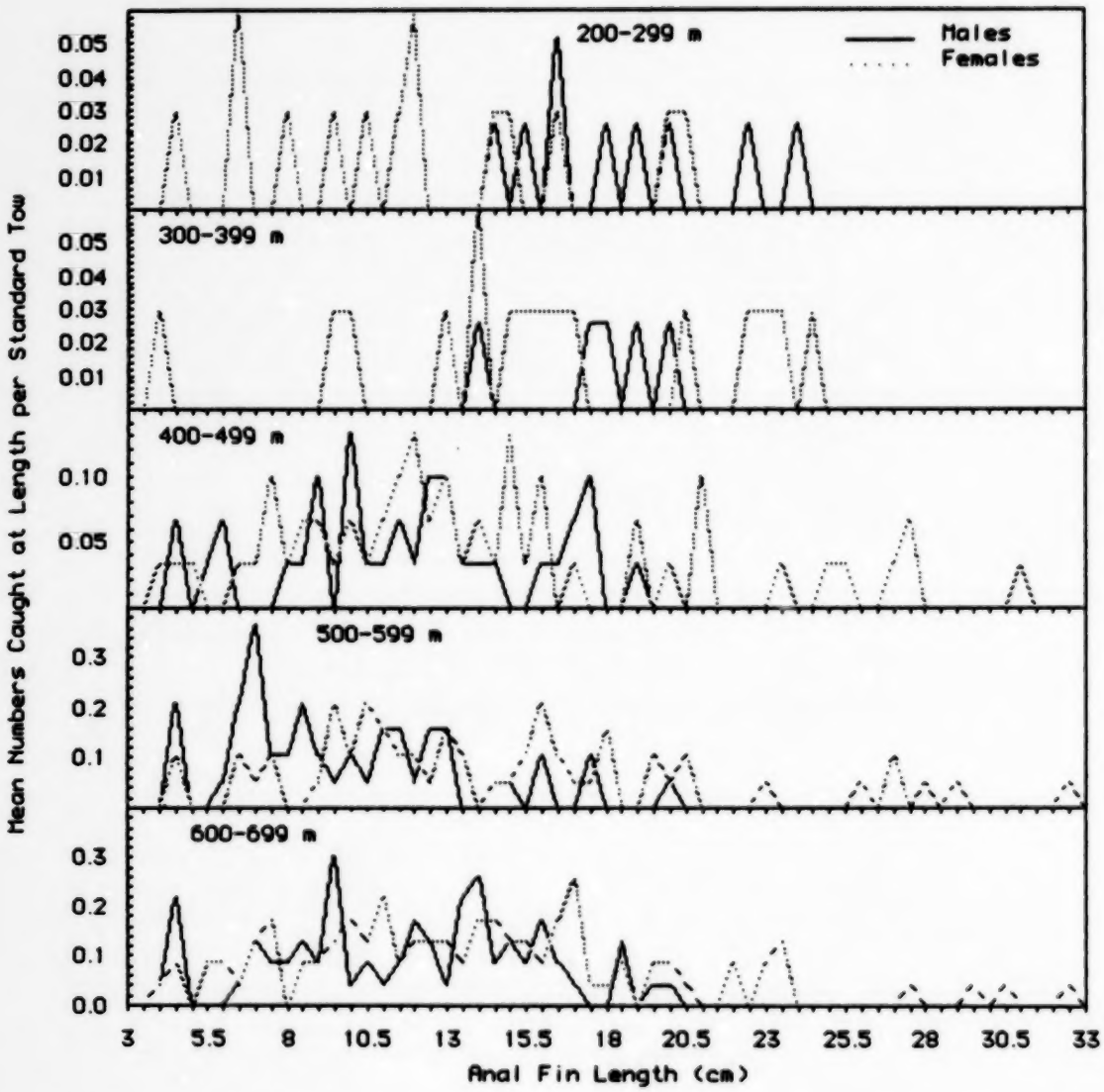

Figure 18: Mean numbers of roughhead grenadier caught per standard tow by depth range during Canadian bottom trawl survey to NAFO SA 0+1 in 1986.

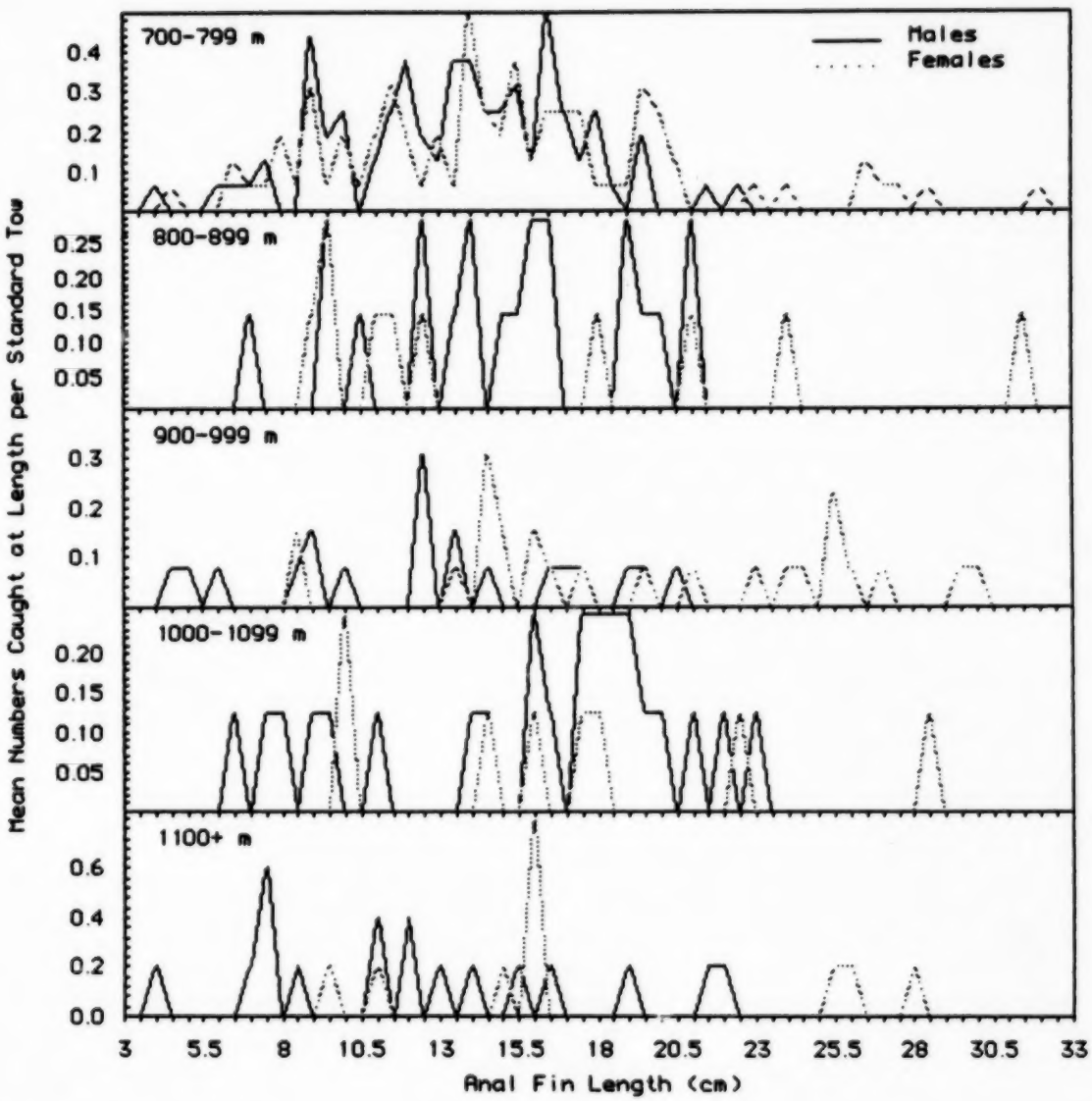

Figure 18: Continued.